FOAMINESS AND COAGULATION OF PROTEIN SOLS:
WITH ESPECIAL REFERENCE TO BREWING PROBLEMS

BY

SYDNEY ROSS

B.Sc., McGill University, 1936

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CHEMISTRY
IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF
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Many of the methods in current practice for the investigation of the properties of proteins can only be applied to mixtures of unknown protein constituents, such as are frequently encountered in the industrial field, to draw broad separations based on some specific difference in property between various fractions. The theoretical value of such distinctions must remain of a dubious character while the practical value has yet to be developed. Thus, for instance, the use of streaming potentials, ultra-centrifuge, spreading characteristics, x-ray diffraction or conductivities, applied to the proteins which exist in cereals or cereal beverages have so far failed to yield any information which could not be better obtained on simpler starting materials by the theoretical chemist, or which could find an immediate practical significance at the hands of the applied chemist.

The purpose of the present research is to broach the problem of suitable instrumental methods of investigation which could be applied to the study of cereal beverages to yield information of service to the manufacturer. At the same time it was realized that it is desirable to avoid the use of purely empirical methods. Throughout the course of the present study a consistent effort is made to relate the observed effects on these complex mixtures with the known colloidal and physico-chemical properties of the systems involved.

The two protein effects of greatest interest to the brewer are turbidities and foaminess. These also happen to be effects which have not been studied to any great extent by the theoretical scientist. Much of the knowledge on the subject has been gathered incidentally during the investigation of manufacturing problems by the industrial research worker. The result is that the literature on the subject lacks correlation, presenting a maze of nomenclature and methods in which individual ingenuity cannot atone for confusion worse confounded.

In the field of protein turbidities terms such as "chill haze," "pasteurization haze," and "oxidation haze" are probably different names for the same phenomenon, whilst in the matter of foaminess few investigators are willing to adopt the same methods of measurement or, if they are compelled to do so since the number of possible methods is limited, the same terms in which to express

their results. The unfortunate consequence is that each new worker is forced to repeat investigations already undertaken in order to test his method or to provide a basis for further results. Without standardized methods, or some measure of correlation, much of the most careful work of the past is incapable of interpretation. Results obtained by one method of measurement are frequently contradicted when the method is altered.

The first object of the present research was to seek some means whereby a little order could be introduced into the chaos of conflicting methods. This has been achieved to some extent, for foam measurements, by the introduction of physico-chemical laws, based on the hypothesis, originally made by Bikerman[1], that the capacity for formation of foam is a physical property of a liquid. The results obtained indicate that not all methods are capable of correlation. The very conditions imposed by the methods used in the formation of the foam may lead to great differences in its character and composition and, even though comparable terms are used to express the results, no agreement could be expected. On the other hand, however, and this is the more valuable result, it was found possible to correlate some methods, previously considered totally different, by the use of a comparable unit of foaminess.

The second part of the research has a more immediate practical application. It is to investigate methods for the rapid coagulation of beer proteins, based on the known colloidal nature of the material. The instrumental method of measurement used for this purpose was nephelometry, without any attempt to interpret the data in terms of number of particles or particle size. The relative measurement of turbidities was found to be sufficiently significant for the purpose in hand.

It is believed that both turbidities and foaminess in cereal beverages are the result of the colloidal properties of the protein constituents. To this extent the present work, especially in the interpretation of results, is a study in colloid chemistry and has reference to any system containing a mixture of proteins. Its immediate practical application in the brewing industry is obvious and inevitable but, it is hoped, in no way detracts from the wider aspect of its theoretical implications.

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[1] J. J. Bikerman, *Trans. Faraday Soc.* 34, 634, (1938).

SUMMARY OF RESULTS

1. An unit of foam stability for static foams has been established, whereby results obtained either by the Carlsberg[2] or the Blom[3] method can be expressed in comparable terms.

2. A further property of this unit of foaminess has been revealed. The foam can be produced either by bubbling the gas through the liquid or, if the liquid already contains a gas in solution under pressure, by allowing it to fall from a height, or merely by shaking it. In each case, the average life of a bubble in the foam is identical within the limits of experimental error.

3. An examination of the brewing literature on the subject of foam stability has shown many methods of expressing the results. If sufficient data are available these can easily be converted into terms of the unit proposed in this study.

4. A method of measuring the foam stability of beer is outlined. This method dispenses with many unnecessary measurements and precautions, requires no arbitrary heights or time intervals, and can be adapted to suit either carbonated or uncarbonated beers.

5. Dynamic and static foam meters, capable of use with any gas to produce the foam, are described.

6. The results of measurements of dynamic and static foams of egg albumin sols are tabulated, for both air and carbon dioxide in the gaseous phase.

7. Evidence for a reaction between carbon dioxide and egg albumin sol is deduced from foaminess data.

8. Units of foaminess for both static and dynamic foams are discussed and methods of foam measurement classified and correlated.

9. The course of the aging of beer is followed nephelometrically and the turbidity found to attain a constant maximum after thirty days aging.

10. Rapid aging has been found to be possible, as indicated by the nephelometric results, on treatment to produce a rapid coagulation of the protein material.

11. The optimum conditions for this treatment were investigated.

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[2] E. Helm, *Wochschr. Brau.* 50, 241, (1933).

[3] J. Blom, *J. Inst. Brewing*, 43, 251, (1937).

12. The foaming capacity of the liquid was found to be unimpaired by the treatment.

13. A reaction mechanism was deduced, based on the known colloidal and chemical properties of proteins, to explain the results obtained.

14. An improved and modified method for the determination of copper in beer by means of the color developed with Sodium Diethyl Dithiocarbamate is described.

VITA

The author was born in Glasgow, Scotland, on July 6, 1915. He was educated privately and at the High School of Glasgow until 1933. He attended McGill University, Montreal, and received the degree of Bachelor of Science, First Class Honours in Chemistry in 1936. In September, 1936, he entered the graduate school of the University of Illinois and held a teaching assistantship in analytical chemistry from 1936-1940. He is a member of Phi Lambda Upsilon, Sigma Xi and Alpha Chi Sigma.

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